The x_F Dependence of ψ and Drell-Yan Production*

R. Vogt

The nuclear target, A, dependence of particle production is conventionally parameterized by a power law as $\sigma_{pA} = \sigma_{pN} A^\alpha$. If production were independent of nuclear matter, $\alpha = 1$. Experiments have measured $\alpha < 1$ and a decrease in α as a function of x_F. There are a number of effects which could contribute to the x_F dependence. The nuclear parton densities are different than those in a free proton. The incoming parton or the final-state $c\overline{c}$ pair could lose energy in nuclear matter. Absorption of the produced ψ or $c\overline{c}$ state by nucleons and/or produced particles can cause ψ suppression. Another effect is a possible intrinsic $c\overline{c}$ component of the projectile.

We compare $\alpha(x_F)$ with the preliminary E866 ψ and ψ' data [1]. Since the E866 targets are tungsten and beryllium,

$$\alpha(x_F) = 1 + \frac{\ln[(A_{\rm Be} d\sigma_{p{\rm W}})/(A_{\rm W} d\sigma_{p{\rm Be}})]}{\ln(A_{\rm W}/A_{\rm Be})} \; .$$

We calculate quarkonium hadroproduction in two ways. The color evaporation model, CEM, treats all charmonium production identically to $c\overline{c}$ production. The more recent non-relativistic QCD approach, NRQCD, involves an expansion of quarkonium production in powers of the relative $q - \overline{q}$ velocity.

We consider three different models of nuclear absorption: either all states are produced as color octets or color singlets or in an octet/singlet combination. Comoving secondaries also scatter with the $c\overline{c}$ pair or the ψ.

The nuclear parton distributions are assumed to factorize into a shadowing function $S^i(A, x, Q^2)$ and the free proton parton distributions $f_i^p(x, Q^2)$. Three different parameterizations of the nuclear shadowing function have been used.

We study three models of energy loss. The first two, GM, from Gavin and Milana, and BH, suggested by Brodsky and Hoyer, deplete the projectile parton momentum fraction, x_1. In the third, KS, from Kharzeev and Satz, the final-state $c\overline{c}$ pair momentum is degraded.

Intrinsic $c\overline{c}$ pairs in the projectile wavefunction are also considered. Since the charm quark mass is large, these intrinsic heavy quark pairs carry a significant fraction of the longitudinal momentum and contribute at large x_F.

To compare with the preliminary data, $\alpha(x_F)$ is calculated by combining all effects. For pure octet absorption, we use all three models of energy loss. Only GM and BH loss is used with pure singlet absorption and the combination of singlet and octet production. The CEM is used to calculate charmonium production for pure octet and pure singlet absorption while NRQCD is used for octet/singlet combination absorption. All three shadowing parameterizations are used. The absorption cross sections are chosen so each S^i agrees with $\alpha(x_F)$ at $x_F > 0$. A 1% probability of intrinsic charm in the proton is assumed. The A dependence of Drell-Yan production is also studied. In this case, only shadowing and energy loss are important.

We find that a single mechanism cannot describe the shape of $\alpha(x_F)$ for all x_F. Combining all effects can explain some portion of the data, depending on which model of energy loss is assumed. A constant energy loss, such as GM, can describe the forward data when combined with the other effects discussed here but results in values of α too large at low x_F. If the BH model of energy loss is correct, a combination of BH loss and shadowing alone cannot describe the data, further strong absorption at large x_F, such as intrinsic charm, is still needed.

[1] M.J. Leitch *et al.* (E866 Collab.), nucl-ex/9909007, submitted to Phys. Rev. Lett.

*LBNL-42294; Phys. Rev. **C**, in press.